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December 22, 1993

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Re: MM Docket No. 93-177

Dear Mr. Secretary:

This letter includes comments of Silliman and Silliman in the matter of MM Docket No. 93-177 with a request to accept a late filing.

Copies have also been included for those listed below.

Very truly yours,

Robert M. Silliman

Robert M. Silliman, PE
Partner

RMS:mee

cc: Mr. William Hassinger, Assistant Chief, Mass Media Bureau
Mr. John Sadler
Mr. Douglas Webbink
Mr. Joseph M. Johnson

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C.

In the Matter of	)	
	)	
An Inquiry into the	)	
Commission's Policies and	)	MM Docket 93-177
Rules Regarding AM Radio	)	RM-7594
Serving Directional Antenna	)	
Performance Verification	)	

Comments of Silliman and Silliman

The Commission is hereby petitioned to accept a late filing in this matter. An unexpected crisis in this consulting firm prevented the material from being filed in time to meet the deadline. The writer believes that the material provided herewith will be of assistance to the Commission in the matter.

INTRODUCTION

The firm of Silliman and Silliman and its predecessor firms have been active in the work of adjusting AM directional antenna systems since before 1950 and have assisted with the adjustment of many AM directional antenna systems.

The evolution of the matter of adjusting such arrays has been set forth in considerable detail in the filings of several other consulting firms. The matter was excellently detailed in the filing by du Treil, Lundin & Rackley, Inc. and will not be restated here.

RULES WHICH ARE INADEQUATE AND SHOULD BE CHANGED

CRITICAL DIRECTIONAL ARRAYS

The Commission adopted rules defining critical directional arrays for which they adopted abnormally strict rules governing maintenance of currents and phases. This rule does not seem to have been uniformly applied and may even have been used to justify the grant of directional arrays which should not have been granted. It is urged that the Rule be dropped and that all directional antenna arrays be treated equally.

ANTENNA BASE CURRENTS

The Rules require the establishment of antenna base current ratios which has never made any sense. What is important is the ratios of the fields and their phases which are not controlled in general by the base current ratios. It is urged that all requirements for measurement of antenna base currents during directional operation be deleted.

MONITORING POINTS

The present Rules require the establishment of MONITORING POINTS which are particular measurement locations at which the allowable field strength is set forth in the station license. It has always been recognized that a single point was not sufficient to monitor the radiation in the direction of the point. Things happen in the vicinity of the point which change the field strength reading at the point without any change in the pattern of the antenna array. Monitoring points should be done away with.

PROOF OF PERFORMANCE FIELD STRENGTH MEASUREMENTS

As time has passed, it has become more and more difficult to make meaningful proof of performance measurements on AM directional antenna systems. It is believed that the time has now come to face up to this situation and consider whether some other method of proving the adjustment of an AM directional array is possible, and eliminate the field measurement part of the proof of performance. The remainder of this statement will be directed to the matter of alternative methods of proving an AM directional antenna array.

MOMENT METHOD OF ANALYSIS

The moment method of analysis was not available to the engineers engaged in the adjustment of directional antenna systems and the filing of Proofs of Performance when the present directional antenna rules were developed. At that time all antenna calculation was based on sinusoidal current distribution on the antenna towers. The engineers knew that the method came up with completely unreasonable values of impedance, base current and voltage so they would make quite large arbitrary corrections based on measurement experience.

The government supported development of the Numerical Electrical Code known as NEC, which, although originally pretty much limited to rather large computers gave us a method of calculating the current and phase distribution on the towers of a directional antenna system and a method of predicting the base impedance, currents and voltages in a manner which was very close to the values which would be determined when the array was built and tuned.

In addition, with the advent of the personal computer, the more simple calculation procedure known as Mininec became available. It is a much more simple program than the Numerical Electromagnetic Code and has provided every consulting engineer with a powerful tool which may be used to provide the calculations referred to in the above paragraph on a small personal computer.

It should be further pointed out that it is now possible to run the full NEC Numerical Electrical Code program on an average sized PC or computer, such as one has in the office. But the writer urges the use of Mininec in preference to NEC if the problem can be solved using Mininec. For example, a directional array of 8 towers each 140 degrees high could be run with a sample point every ten degrees and would have 112 variables. It could be run on Mininec although this is close to the limit for use of Mininec.

PROBLEM OF OBTAINING EXACT FIELD RATIOS FROM A NEC OR MININEC RUN

One problem with the use of Method of Moments is that one must input the proper individual driving point voltages to obtain the solution. There are various tricks for approximating this. However, it is desired to call attention to a solution to this problem presented in the IEEE TRANSACTIONS ON BROADCASTING by Jerry Westberg which will be referenced in this statement.

His solution is to run the moment method solution once for each element of the array applying a voltage applied to just one tower and grounding the other towers. These solutions are then combined in a matrix analysis to give the exact input voltages and currents required to provide the desired field ratios and phases. This is a powerful method and works very well. An example will be supplied to demonstrate the working of the approach.

Although almost all engineers working on AM directional antenna adjustment have access to Mininec, the writer finds that not all have a convenient method in house of handling the Matrix equations called for in the Westberg Article. It has been decided to provide an example of such a solution making use of an inexpensive commercially available mathematics program costing less than $150. The program selected is Mathcad 4.0 purchased from MathSoft Inc.,201 Broadway, Cambridge, Massachusetts 02139.

It was decided to include an example of a solution as Exhibit 1 of this statement. Furthermore, to make it easier to follow it was decided to include the calculation of the example in Westberg"s Paper so that the procedure can be followed while referring to the Westberg Paper rather than using an original example with more towers as had been first considered.

The example carries out the calculations of the Westberg paper using Mathcad 4.0. It should be mentioned that the values in the T Matrix are the values in the Westberg paper. Had more decimal places been employed in this Matrix, the values would be slightly different.

Westberg, J. M. (June 1989) Matrix Method for Relating Base Current Ratios of AM Directional Stations, Volume 35, No. 2, p. 172 of IEEE TRANSACTIONS ON BROADCASTING

A SUGGESTION WITH REGARD TO DIRECTIONAL ANTENNA PROOF OF PERFORMANCE

The following is a suggestion for an alternative to the present Proof of performance.

A station may propose the following alternative method for proof of performance measurements provided the station complies with all of the following requirements.

(1) A moment method solution of the directional array for which the calculated field ratio and phase shall be in agreement with the authorized field ratio and phase within 1 degree and 1 percent. See example for the exact method of determining field ratio and phase from the moment method solution.

(2) A measurement of the common point impedance over a frequency range of carrier plus and minus 20 kHz should be provided.

(3) Measurements should be provided of the electrical length of the sampling lines at the operating frequency. This may be done by measurement of the frequency as close to the operating frequency as possible at which the open or short circuited sampling lines are resonant.

(4) Measurement should be obtained from the antenna monitor of the tower relative voltage ratios and phases or of the sample currents and phases obtained from an unshielded single turn loop mounted ten feet above the base for towers shorter than a quarter wave or near the current loop for towers longer than a quarter wave. The sample point should coincide with a calculation point of the Mininec Solution.

Robert M. Silliman

By Robert M. Silliman

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December 15, 1993

EXHIBIT 1

It will be an example of the method of Jerry Westberg using the Mathcad Math Program
This will be the example in Westberg's Article

The Y matrix expresses the base current of a tower resulting from 1 volt into a single tower with the other towers grounded.

$$Y := \begin{pmatrix} .0078308 - .0080983i & .00203874 + .00094628i \\ .00203874 + .00094628i & .00159442 - .00174005i \end{pmatrix}$$

$Z := Y^{-1}$ The Z matrix will be the inverse of the Y matrix

$$Z = \begin{pmatrix} 47.625541 + 60.079513i & 40.823662 - 60.535109i \\ 40.823662 - 60.535109i & 219.545126 + 292.773692i \end{pmatrix}$$

$$T := \begin{pmatrix} .0457 - .0592i & .0119 + .0056i \\ .0156 + .0069i & .0120 - .0334i \end{pmatrix}$$

The T matrix gives the relative fields resulting from 1 volt into each tower with the other towers grounded

$S := T^{-1}$ Westberg's S matrix is obtained by inverting the T matrix

$$S = \begin{pmatrix} 7.428375 + 9.851939i & 3.895355 - 2.394343i \\ 4.978204 - 3.222836i & 8.513062 + 24.567507i \end{pmatrix}$$

$H := Y \cdot S$ His H matrix is obtained by multiplying the Y matrix by the S matraix

$$H = \begin{pmatrix} 0.151153 + 0.015132i & 0.005222 + 0.007847i \\ 0.008151 + 0.013314i & 0.066529 + 0.023162i \end{pmatrix}$$

$$F := \begin{pmatrix} 1 + 0i \\ 0 - .8i \end{pmatrix}$$

Next form a column vector which expresses the desired field ratio

$V := S \cdot F$ A base voltage column vector is obtained by multiplying the S matrix by the desired field ratio column vector F

$$V = \begin{pmatrix} 5.5129 + 6.735655i \\ 24.63221 - 10.033286i \end{pmatrix}$$

Using pocket calculator
V=8.70385 at angle 50.70 over
26.5972 at angle -22.2 = base voltage
= 1 at angle 0 over ratio
3.056 at angle -72.9

$I := H \cdot F$

$$I = \begin{pmatrix} 0.157431 + 0.010954i \\ 0.026681 - 0.03991i \end{pmatrix}$$

= 1 at angle 0 over = base current ratio
.3042 at angle -60.2